

WE CLAIM:

1. A fastening system installation tool for installation of a fastening system to a structure, said tool comprising:
  - an outer housing having an interior hollow, a gage surface, and a base surface, said base surface having a contact area that contacts the surface
  - 5 of the structure;
  - an inner plug disposed within said interior hollow and that translates axially within said interior hollow, wherein:
    - said inner plug has a sensing end that contacts the fastening system;
    - 10 said inner plug has an indicator end dimensioned to accept washers and nuts of the fastening system stacked on said gage surface; and
    - said inner plug has an indicator at said indicator end that indicates whether a fastening system component conforms to a fastening system installation specification.
2. The fastening system installation tool of claim 1, wherein said indicator provides installation information, according to a qualitative requirement, about components of the fastening system being installed using said tool.
3. The fastening system installation tool of claim 1, wherein said indicator provides installation information, according to a dimensional requirement of a fastening system installation specification, about components of the fastening system being installed using said tool.
4. The fastening system installation tool of claim 1, wherein said sensing end of said inner plug has an axial bore, said axial bore having a diameter greater than the thread diameter of a bolt of the fastening system but

less than the shank diameter of a bolt of the fastening system.

5. The fastening system installation tool of claim 1, wherein said indicator of said inner plug includes a color band, a thickness of said color band correlating to a dimensional requirement of the fastening system installation specification.

6. The fastening system installation tool of claim 1, wherein said indicator of said inner plug includes a plurality of color bands and each of said color bands corresponds to an available washer thickness of the fastening system.

7. The fastening system installation tool of claim 1, wherein said indicator end of said inner plug includes a plurality of color bands, a thickness of each said color band correlating to a distinct dimensional requirement of the fastening system installation specification.

8. The fastening system installation tool of claim 1, wherein said indicator of said inner plug includes a shoulder, a position of said shoulder correlating to a dimensional requirement of the fastening system installation specification.

9. The fastening system installation tool of claim 1, wherein said indicator of said inner plug includes an index marking, a position of said index marking correlating to a dimensional requirement of the fastening system installation specification.

10. The fastening system installation tool of claim 1, wherein said indicator of said inner plug provides installation information about a washer stacked on said gage surface.

11. The fastening system installation tool of claim 1, wherein said indicator of said inner plug provides installation information about a nut stacked on said gage surface.

12. The fastening system installation tool of claim 1, wherein said inner plug references an end of a bolt of the fastening system.

13. The fastening system installation tool of claim 1, further including:  
a plunger that references an end of a bolt of the fastening system, said plunger having an indicator that provides installation information, according to a dimensional requirement of a fastening system installation specification,  
5 about components of the fastening system being installed using said tool, and wherein:

said sensing end of said inner plug has an axial bore, said axial bore having a diameter greater than the thread diameter of a bolt of the fastening system but less than the shank diameter of a bolt of the fastening  
10 system; and

said inner plug includes a dome, said dome having an axial opening that guides an axial translation of said plunger.

14. A fastening system installation tool for installation of a fastening system to a structure, said tool comprising:

an outer housing having an interior hollow, a gage surface, and a base surface, said base surface having a contact area that contacts the surface  
5 of the structure;

an inner plug disposed within said interior hollow and that translates axially within said interior hollow, wherein:

said inner plug has a sensing end that contacts the fastening system;

10 said inner plug has an indicator end dimensioned to accept washers and nuts of the fastening system stacked on said gage surface; and

said inner plug has an indicator on said indicator end that indicates whether a fastening system component selection allows conformance to a qualitative requirement of a fastening system installation specification.

15. The fastening system installation tool of claim 14, wherein:

said fastening system component selection is a bolt selection comprising a selected bolt;

5 said sensing end of said inner plug references the end of the selected bolt of the fastening system; and

said indicator of said inner plug is readable in conjunction with said gage surface to indicate whether the bolt selection allows conformance to the fastening system installation specification.

16. The fastening system installation tool of claim 14, wherein:  
said fastening system component selection is a washer selection comprising a selected washer;  
said sensing end of said inner plug references the shank section  
5 of a bolt of the fastening system; and  
said indicator of said inner plug is readable in conjunction with the selected washer stacked on said gage surface to indicate whether the washer selection allows conformance to the fastening system installation specification.
17. The fastening system installation tool of claim 14, wherein:  
said fastening system component selection is a nut selection comprising a selected nut;  
said sensing end of said inner plug references the shank section  
5 of a bolt of the fastening system; and  
said indicator of said inner plug is readable in conjunction with the selected nut stacked on said gage surface to indicate whether the nut selection allows conformance to the fastening system installation specification.
18. The fastening system installation tool of claim 14, wherein said outer housing has a base plate with a contact area that is a flat annular surface.
19. The fastening system installation tool of claim 14, wherein said sensing end of said inner plug has an axial bore, and said axial bore is threaded to fit the threads of a bolt of the fastening system.
20. The fastening system installation tool of claim 14, wherein said indicator of said inner plug includes a shoulder, a position of said shoulder correlating to a dimension requirement of the fastening system installation specification.

21. The fastening system installation tool of claim 14, wherein said indicator of said inner plug includes a first shoulder and a second shoulder, a distance between said first shoulder and said second shoulder correlating to a dimension requirement of the fastening system installation specification.

22. A system for installation of a fastening system to a structure, said system comprising:

a fastening system installation specification including dimensional requirements for components of a fastening system; and

5 a tool including:

an outer housing having an interior hollow, a gage surface, and a base surface, said base surface having a contact area that contacts the surface of the structure;

10 an inner plug disposed within said interior hollow and that translates axially within said interior hollow, wherein:

said inner plug has a sensing end that contacts a bolt of the fastening system and references the shank section of a bolt of the fastening system;

15 said inner plug has an indicator end dimensioned to accept washers and nuts of the fastening system stacked on said gage surface; and

20 said inner plug has an indicator on said indicator end that provides installation information according to said fastening system installation specification about components of the fastening system being installed using the tool.

23. The system of claim 22, wherein said sensing end of said inner plug references the end of a bolt of the fastening system and said indicator end of said inner plug has an indicator that is readable in conjunction with said gage surface to indicate whether the bolt satisfies a minimum pin protrusion  
5 dimensional requirement of said fastening system installation specification.

24. The system of claim 22, wherein said sensing end of said inner plug references the end of a bolt of the fastening system and said indicator end of said inner plug has an indicator that is readable in conjunction with said gage surface to indicate whether the bolt satisfies a maximum pin protrusion  
5 dimensional requirement of said fastening system installation specification.

25. The system of claim 22, wherein said sensing end of said inner plug references the shank section of a bolt of the fastening system and said indicator end of said inner plug has a threads-in-bearing indicator that is readable in conjunction with said gage surface to indicate whether the bolt  
5 satisfies a no threads in bearing requirement of said fastening system installation specification.

26. The system of claim 22, wherein said sensing end of said inner plug references the shank section of a bolt of the fastening system and said indicator end of said inner plug has a shanking indicator that is readable in conjunction with a washer stacked on said gage surface to indicate whether the  
5 washer satisfies a no shanking requirement of said fastening system installation specification.

27. The system of claim 22, wherein said sensing end of said inner plug references the shank section of a bolt of the fastening system and said indicator end of said inner plug has a thread bolt protrusion indicator that is readable in conjunction with a nut stacked on said gage surface to indicate  
5 whether the nut satisfies a minimum thread protrusion requirement of said fastening system installation specification.

28. An installation system for installing aerospace fastening systems to a structure, said installation system comprising:  
an installation guide in accordance with qualitative requirements for components of a fastening system; and  
5 a tool including:  
an outer housing having an interior hollow, a gage surface, and a base surface, said base surface having a flat contact area that contacts the surface of the structure;  
an inner plug disposed within said interior hollow and that  
10 translates axially within said interior hollow, wherein:  
said inner plug has a sensing end with an axial bore that contacts the fastening system, and said sensing end references the shank section of a bolt of the fastening system;  
said inner plug has an indicator end;  
15 a transducer connected between said outer housing and said inner plug, and that measures a relative displacement between said inner plug and said outer housing; and  
an electronic instrumentation connected to said transducer and that provides and displays installation information according to said installation  
20 guide about whether the bolt, washer, and nut components of the fastening system being installed using the tool will conform to a fastening system installation specification.



29. The installation system of claim 28 wherein said installation guide includes a prescription for a washer stack corresponding to said relative displacement measured by said transducer.

30. The installation system of claim 28 wherein said installation information includes a prescription according to said installation guide for a washer stack corresponding to said relative displacement measured by said transducer.

31. The installation system of claim 28 further comprising:  
a plunger that references an end of a bolt of the fastening system,  
wherein:

5       said inner plug includes a dome, said dome having an axial  
opening that guides an axial translation of said plunger; and  
      said transducer is connected to said plunger.

32. A method for installing aerospace fastening systems to a structure,  
comprising the steps of:

      seating a base of an outer housing of a tool to a surface of the  
structure;

5       referencing a shank section of a bolt of the fastening system with  
an inner plug of said tool;

      reading a threads-in-bearing indicator of said inner plug in  
conjunction with a gage surface of said outer housing;

10       replacing the bolt when said threads-in-bearing indicator is not  
above said gage surface; and

      installing the bolt when said threads-in-bearing indicator is above  
said gage surface.

33. The method of claim 32, wherein said replacing step is performed due to not meeting a no threads in bearing requirement of a fastening system installation specification.

34. The method of claim 32, wherein said inner plug of said tool has a shanking indicator and further comprising steps of:

- stacking a first washer on said gage surface to form a stack;
- reading a shanking indicator of said inner plug in conjunction with
- 5 the top of the stack;
- adding an additional washer to the stack when the top of the stack is below said shanking indicator; and
- adding a nut to the stack when the top of the stack is not below said shanking indicator.

35. The method of claim 34, wherein said adding an additional washer step is performed due to not meeting a no shanking requirement of a fastening system installation specification.

36. The method of claim 32, further comprising steps of:

- reading a thread bolt protrusion indicator of said inner plug in conjunction with a nut stacked on said gage surface;
- replacing the nut when the top of the nut is above said thread bolt
- 5 protrusion indicator; and
- installing the nut when the top of the nut is below said thread bolt protrusion indicator.

37. The method of claim 32, further comprising steps of:  
reading a thread bolt protrusion indicator of said inner plug in  
conjunction with a nut stacked on said gage surface;  
replacing the bolt when the top of the nut is above said thread bolt  
5 protrusion indicator; and  
installing the nut when the top of the nut is below said thread bolt  
protrusion indicator.

38. The method of claim 36, wherein said replacing step is performed  
due to not meeting a complete nut engagement requirement of a fastening  
system installation specification.

39. The method of claim 37, wherein said replacing step is performed  
due to not meeting a complete nut engagement requirement of a fastening  
system installation specification.

40. A method for installing aerospace fastening systems to a structure,  
comprising the steps of:  
inserting a bolt of the fastening system in a hole of the structure;  
checking for a protrusion of a shank section of the bolt above a  
5 surface of the structure;  
replacing the bolt when the shank section does not protrude above  
the surface of the structure;  
seating a base of an outer housing of a tool to a surface of the  
structure;  
10 referencing a shank section of a bolt of the fastening system with  
an inner plug of said tool;  
stacking a first washer on a gage surface of said tool to form a  
stack;  
reading a shanking indicator of said inner plug in conjunction with

- 15 the top of the stack; and  
adding an additional washer to the stack when the top of the stack  
is below said shanking indicator.

41. The method of claim 40, wherein said replacing step is performed  
due to not meeting a no threads in bearing requirement of a fastening system  
installation specification.

42. The method of claim 40, further comprising a step of:  
adding a nut to the stack when the top of the stack is not below  
said shanking indicator.

43. The method of claim 40, wherein said adding an additional washer  
step is performed due to not meeting a no shanking requirement of a fastening  
system installation specification.

44. A method for installing an aerospace fastening system to a  
structure, comprising the steps of:

- seating a base of an outer housing of a tool to a surface of the  
structure;  
5       referencing a shank section of a bolt of the fastening system with  
an inner plug of said tool;  
reading an indicator of said tool to determine a prescribed washer  
stack for the fastening system.

45. The method of claim 44, wherein said step of reading an indicator  
includes reading an output display generated from a transducer connected to  
said tool.

46. The method of claim 44, further comprising a step of:  
installing a washer stack as prescribed from reading said indicator.

47. The method of claim 44, wherein said prescribed washer stack is prescribed according to an installation guide in accordance with a fastening system installation specification.

48. A method for eliminating trial and error in installing an aerospace fastening system to a structure, comprising the steps of:

querying at least one dimension of the actual fastening system hardware using a fastening system installation tool having an inner plug, with  
5 indicators, disposed to axially translate within an outer housing; and  
determining an actual washer stack to install on the fastening system so that said fastening system installation conforms to a qualitative requirement.

49. The method of claim 48 wherein said qualitative requirement is chosen from the group consisting of: (1) no "threads in bearing"; (2) no "shanking"; and (3) complete nut engagement.

50. The method of claim 48 wherein said querying step includes measuring a thread length of an actual bolt of the fastening system.

51. The method of claim 48 wherein:  
the actual fastening system hardware is applied to the structure;  
and

said querying step includes measuring a protrusion through the  
5 structure of an actual bolt of the fastening system.

52. The method of claim 48 wherein said querying step includes querying a washer of the fastening system.

53. The method of claim 48 wherein said querying step includes querying a nut of the fastening system.

54. An automated fastening machine including:  
an outer housing having an interior hollow, a gage surface,  
and a base surface, said base surface having a flat contact area;  
an inner plug disposed within said interior hollow and that  
5 translates axially within said interior hollow, wherein:  
said inner plug has a sensing end with an axial bore,  
and said sensing end contacts a fastening system and references the shank  
section of a bolt of the fastening system; and  
said inner plug has an indicator end;  
10 a transducer connected between said outer housing and said inner  
plug, and that measures a relative displacement between said inner plug and  
said outer housing; and  
an electronic instrumentation connected to said transducer.

55. The automated fastening machine of claim 54 wherein:  
said electronic instrumentation is a controller that controls  
installation of the fastening system being installed by said automated fastening  
machine.

56. The automated fastening machine of claim 54 wherein:  
said electronic instrumentation uses a signal from said transducer  
to decide whether a bolt, washer, and nut components of the fastening system  
being installed using the automated fastening machine will conform to a  
5 fastening system installation specification.